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### Science and innovation in Scotland

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# **Science and innovation dynamics and policy in Scotland: The perceived impact of enhanced autonomy**

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## **Abstract**

The Scottish referendum of 2014 encouraged massive public debate, including on Scotland's scientific performance and ability to harness innovation and increase global competitiveness. The science base in Scotland has traditionally been strong but has not translated well into innovation. This article uses statistical data, over 30 interviews and two workshops with business and policy leaders, to analyse key scientific and industrial innovation dynamics, using a regional innovation systems (RIS) approach. It investigates the perceived impact of increased autonomy on the dynamics of the Scottish innovation system (SIS). The article shows the weak relationship between science and innovation and evidences the static nature of Scottish innovation policy geared to bridging a gap rather than improving the dynamics of the various elements in the innovation system. It suggests that an approach which aims to spur evolution in specific elements of the territorial governance system would strengthen Scottish innovation capabilities.

## **Keywords**

science

innovation dynamics

increased autonomy

Scotland

innovation capabilities

governance

## **1. Introduction**

The Scottish independence referendum of September 2014 was the setting for high public engagement, and debate included questions on how to harness innovation to increase Scotland's international competitiveness.

Regardless of the referendum result, Scotland's ability to be a top-level knowledge producer and innovative region remains a matter of interest (Scottish Enterprise [SE] 2006; Roper et al. 2007; Scottish Government 2008, 2013). The UK Government Command Paper (HM Government 2015) contained clauses to increase powers for the Scottish Parliament/Executive. In particular, the Scottish Government will be able to collect roughly 40 per cent of its budget and be responsible for about 60 per cent of all public expenditure.

Scotland is set to enjoy a high degree of fiscal autonomy, in an otherwise fairly centralized UK system of governance. For these reasons revisiting Scotland's scientific and innovation capacities, and the perceptions held by different stakeholders on how capacities may be impacted by changes in Scotland's institutional structures, will help future research and policy-making. This article summarizes the strengths and weaknesses perceived and measured in its science and innovation system,

assesses policy initiatives to improve them, and interrogates the arguments made by the Scottish Government regarding how independence, or further devolution, could lead to a more prosperous Scotland.

The independence narrative rests strongly on the argument that increased autonomy will provide major opportunities for new policies that will ‘step change’ society and economy: with better opportunities for investment, employment and improved well-being. The science system has been strengthened. However, increased autonomy since 2000 has not significantly helped industrial innovation. In particular this research addressed questions about the relationship between the science base and Scotland’s innovation system and the lack of coherent policy to address the weakness of that relationship, as well as policies towards industrial innovation more generally:

- What impact would increased autonomy have on the ability of Scottish business to absorb knowledge and apply it to innovative activity? (RQ1)
- What impact would increased autonomy have on the organizations that support Scottish businesses in their innovative activities, R&D, technology transfer, commercialization and finance? (RQ2)
- What impact would increased autonomy have on Scotland’s economy in terms of new path creation and resilience? (RQ3)

This article argues that answers to these questions involve going far beyond the prevailing focus on the paradox between strong higher education and research on the one hand, and weak business innovation and entrepreneurship on the other (Technopolis Group 2012) and consequent emphasis on bridging a statically conceived gap between science and its application in innovation. A more far-reaching approach is required if Scotland is to take advantage of increased autonomy with a

focus on innovation systems issues, such as: the innovation trajectories and dynamics of firms within the Scottish innovation system (SIS); and investigation of the evolution of economic systems in Scotland. It is easy to focus on local innovation policies whilst ignoring potentially countervailing macro-economic and financial policies.

The article first traces the Scottish science system, and the relationship between science and innovation, using a regional innovation systems (RIS) perspective (Cooke 1992). This is followed by analysis of the tenuous level of connection between science and innovation. The article will outline the different perspectives of the business and policy communities regarding Scotland's innovation system, regarding enhanced autonomy and its possible impact. It pinpoints weaknesses of the SIS that need addressing to transform Scotland's innovation environment. Finally, it presents a summary of the future prospects for science and innovation and an evidenced argument for a policy led by a focus on new and transformed industrial sectors.

## **2. Method**

To address the research questions, we first examine the existing conditions for science and innovation in Scotland. Our data collection is framed by the RIS theoretical framework that includes awareness of evolutionary system change and the importance of institutional factors beyond the region in terms of market access, knowledge creation and other inputs (Cooke et al. 1997; Morgan 2007). We reviewed the RIS and related literatures, as well as analysing the policy documents concerning science and innovation in Scotland over the past twenty years.

We used Asheim et al. (2011) to better understand the generic weaknesses of RIS theory, and recent advances, then considered how our research might be used to shed light on the SIS. We also analysed the data for science and innovation in Scotland, together with data on innovation infrastructure and structural features of the economy. We used the Scopus database, OECD iLibrary, Office of National Statistics (ONS) figures, and Higher Education Information Database for Institutions (HEIDI) to develop an overview of publication record, patent data, research funding, and higher education income in Scotland.

This data collection was supplemented with information gathering from engaged practitioners, using in-depth semi-structured interviews, undertaken in 2013 and early 2014. The overall approach in selecting interviewees was: first, we interviewed ten people who held overview knowledge and experience of Scottish science and innovation, as well as practitioners positioned at the interface of science and innovation in Scotland. Second, we undertook a further twenty interviews with senior business leaders, policy-makers and academics. The interviewees worked in six key industrial sectors of the Scottish economy – life sciences, information and communication technology (ICT), energy, engineering, food/drink and financial services. The material collected was interpreted through analysis and coding to bring out major themes.

Finally, two workshops were held. In November 2013, a full day workshop of sixteen researchers, government and industry on the future of Scottish science and innovation ran scenarios in two breakout sessions. The participants were asked to think about the future of science and innovation in Scotland under Yes/No scenarios concerning possible independence and also leaving the EU, the latter because of its obvious importance for future innovation policy. Then, they were asked to discuss in more

detail the barriers and opportunities for Scottish science and innovation under a Yes scenario for Scottish independence. A final one-day workshop was held in March 2014 with the objective of testing our results with twelve senior policy-makers and business leaders. Both workshops were fully recorded for transcription and analysis.

### **3. The SIS before devolution**

The strength of Scottish science and industry was already lauded during the Edwardian era, and continued up to World War II, from which point a narrowing of performance between English and Scottish science occurred, and industrial fortunes began to shift away from Scotland (Edgerton and Hughes 1993).

Despite these changes, Scotland in the 1980s was still described as ‘an economy carrying out substantial levels of research in both the private and public sectors, with a total R&D intensity significantly higher than that for economies of comparable size’ (Edgerton and Hughes 1993: 11). Yet scientific strength, R&D capacity, and innovative activity were mostly concentrated in the universities, and in the subsidiaries of large multinational companies (MNCs).

Edgerton and Hughes (1993), who published before the collapse of the multinational branch plant subsidiaries, mapped the massive drop in government R&D in the 1980s, particularly the fall in government support for industrial R&D but showed that 1.8% of Scotland’s GDP was spent on R&D, and that Scotland did as much R&D as Austria, Norway and Denmark. They also showed Scotland’s ‘comparative advantage’ in university education with about 14% of UK academic staff, though Scotland’s share of research council funding at that time was lower than now at no more than its population share (8.8% of UK population in 1991).

Edgerton and Hughes' research was a useful benchmark from which to analyse the post-devolution period, compare its policy proposals with what happened in the last twenty years, but also with the future possibilities for science and technology in Scotland.

#### **4. Mind the gap: UK and Scottish science and innovation policy**

##### ***4.1 Innovation theory and the region***

To analyse Scotland's economic development, it is pertinent to highlight and counter some myths concerning innovation, that: innovation comes from science and R&D alone; R&D is led by R that comes out of universities and research institutes; high tech and radical innovation is best; knowledge exchange and technology transfer are easy and smooth; and firms are solely recipients of science for innovation (Forbes and Wield 2001). These myths are understood as such by policy-makers but, in practice, they continue to inform much science and technology policy.

Innovation is at the heart of growth, adding value that requires technical and organizational change, within the firm primarily, and within industrial sectors, clusters and networks where firms are located. Value addition is path dependent and evolutionary; transformation of firms and their sectors and clusters is difficult and involves gradual changes in work practices; absorptive capabilities of firms, sectors and clusters can evolve only slowly, especially if they are not targeted specifically; missing and weak skills must be generated in an explicit way; and design and engineering matter as much as R&D.

One focus in this study was whether enhanced autonomy would make any substantial difference in local firms' ability to absorb knowledge and skills from local and/or



external sources. The issues of ‘learning’ and ‘absorptive capacity’ (Cohen and Levinthal 1990) are seen as crucial in the systems of innovation and knowledge-based view of the firm literatures. The regional system itself is often depicted as a complex configuration of knowledge assets and cognitive networks, whose architecture and internal routines shape research/industrial activities vis-à-vis processes of knowledge creation, transfer and exploitation, as well as determining asymmetries in knowledge endowments that ultimately lead to competitive advantage (Florida 1995; Morgan 2007).

Devolution in Scotland brought the opportunity, and saw many initiatives, to rebalance innovative efforts and build innovative capabilities. Our argument, however, is that the historical focus in the SIS to build the science base still dominates, as is the secondary focus on bridging the gap between that base and the existing productive and service sectors. Asheim et al.’s (2011) theoretical insights allow us to improve understanding of the Scottish productive economy since they go beyond innovation cluster approaches to include thinking on: regional learning processes and institutions; connectivity between market and non-market actors; going beyond ‘shallow’ firm cluster policy approaches to take a systemic perspective and consider the networks required for cooperative evolution; and, the need to better understand dynamics of RIS, in particular the factors that shape the evolution and performance of knowledge intensive sectors. Asheim et al. (2011) categorize three theoretical gaps in RIS that need further work:

- 1       the effectiveness of RIS for regional advantage (coded as RA);
- 2       openness and connectivity of innovation systems (OC);
- 3       human capital, knowledge learning in regional labour markets (KL).

We use these three categories to analyse our data. Our study of increased autonomy in Scotland allows us to consider some of these perceived weaknesses. In particular, we show that the SIS needs to deal with problems such as: weak connectivity between science and innovation capacity; low absorptive capacity between some key sectors of the economy; and low ability to translate high levels of educational attainment into organisational learning, in order to ‘construct regional advantage’ (Asheim et al. 2011: 1).

#### ***4.2 Scottish policy evolution***

Devolution in 1999 brought autonomy for the Scottish parliament and government on a range of issues that relate to knowledge base development, research and science funding. The Scottish Government allocates the budget for the economic growth strategy, which covers research and innovation. The Scottish Funding Council (SFC) is responsible for teaching and learning, science and research, knowledge exchange, innovation and other activities in Scotland’s higher education institutes. It has developed some original approaches, for example:

- A ‘pooling’ initiative to strengthen research in subject areas where scale and strength could be improved through Scotland-wide collaboration.
- A fund for innovative activities, used to attract big research initiatives to Scotland
- A set of Innovation Centres, from 2012, to help link Scottish research with industrial innovation (digital health, stratified medicine, sensors and imaging systems, industrial biotechnology, oil and gas, construction, aquaculture and data lab).

In addition, Scotland benefits from the support provided by UK-wide bodies, including: the seven research councils that fund research, collectively called Research Councils UK (RCUK); and Innovate UK (IUK), the agency that supports UK-wide development and commercialization of research.

With regard to industrial innovation, the Scottish Development Agency (SDA) was established in 1975 in response to the significant decline of Scotland's traditional industries. In the 1980s, it moved from supporting the restructuring of traditional industries to encouragement of new high tech industries into Scotland. Early success was not sustained into the 1990s as much of the relocated 'branch-plant' industry could not compete with East Asia. The SDA's successor, Scottish Enterprise (SE), attempted to build on the strength of a range of industries, such as oil and gas, finance, chemicals, electronics, food and drink (beef, fish, whisky), and to start a life science sector. SE took up a cluster development strategy (SE 1996) that aimed to build on areas of scientific and industrial strength; for example, the biotechnology sector was identified by SE as a high priority, mostly based on the research capacity in Scotland's university sector rather than any actual industrial presence.

These interventionist approaches continued after devolution. SE pursued a multi-strand innovation strategy, outlined in *Smart, Successful Scotland*, (SE 2001). This included a Business Growth Fund, Proof of Concept Fund, SMART Awards; Scottish Co-Investment Fund, and the creation of the Intermediary Technology Institutes (ITIs) in three cluster areas, though the ITIs had quite a short and unsuccessful life, with their failures analysed by Brown et al. (2015). SE programmes have been successful in creating an extensive business angel network; encouraging growth in different technology sectors; facilitating spin-outs from universities; and raising Scotland's profile in the knowledge economy. More recently, Scotland has become an

active participant in European initiatives such as a growth strategy based on ‘Smart Specialisation’ (Scottish Government 2015).

Several reviews of the SIS have been published (Roper et al. 2007; Coad and Reid 2012; Levie et al. 2013), which praise Scotland’s scientific R&D performance in the universities but note the low connectivity between the scientific knowledge created in Scottish universities and the knowledge demands and capacities of local Scottish firms.

### ***4.3 Strong science and its weak link to innovation***

Corresponding to the image of scientific excellence, the science base in Scotland has traditionally been strong (Scottish Science Advisory Committee 2009; The Scottish Government Office of the Chief Scientific Advisor 2007). We used research publications per million population from 1996 to 2012 as an indicator of this strength to avoid the problems with absolute publication records and output per GDP.

For example, Scotland performs very well in the life sciences, though not quite as well as other small prosperous European nations. Figure 1 presents the data from 1996 to 2012. Scotland’s performance in physical sciences is also excellent (Figure 2).

Figure 1 here

Figure 2 here

Scotland’s science is relatively strong, but not best suited to its local productive industrial needs. Innovation indicators show a mixed message. One indicator of innovation – albeit contested – is the patent record, which is relatively poor. Scotland

generates significantly fewer patents than countries like Finland, Japan, Germany, United States and even less than the UK average (OECD stats).

The strengths in science do not map onto the existing industrial system in Scotland. Our data show a weak link between science and industrial innovation capabilities in Scotland with weak improvement since devolution. In terms of RIS, our research illustrates the importance of considering the key areas pinpointed as weak by Asheim et al., namely: the link between regional innovation and regional competitive advantage; the relationship between ‘shallow’ clusters and strong networks; and the importance of labour markets and regional learning.

In comparison to the arc of prosperity (Scandinavian) countries, Scotland appears to be weak in networking, opportunity perception, process innovation, product innovation, high-growth aspirations, and quality of human resource, while it is strong in technology, competition, opportunity start up, and cultural support variables. In general, the data suggest that Scotland is weaker in areas that relate to attitudes and aspirations and lacks strength in forming and harnessing collaborations and networking (Figure 3).

Figure 3 here

## **5. The future of Scottish science and innovation**

The 2014 referendum drove a significant debate about the nature of innovation in Scottish society and economy, and under what conditions it might better harness its scientific and innovative strengths and address weaknesses. The UK government and Scottish government detailed very different scenarios for science after independence. The Scottish Government white paper (2013) claimed that independence would lead

to a stronger Scottish economy through Scottish control of fiscal and monetary policy, and thereby provide a more business and innovation friendly environment. It argued that a more ‘coherent framework for supporting innovation across the economy’ would be possible, and that it could be targeted specifically at key areas of strength and weakness (2013: 111). It also argued that it would be better able to use specific policy levers, including ‘financing levers such as the provision of loans and guarantees, competitive grants, innovation vouchers, the establishment of an Innovation Agency or Institute’ and the indirect levers of tax-based incentives (2013: 111). This could all be achieved while retaining what it called the current integrated ‘common research area’ (i.e. the current UK research system). However, the specific structural targets, and how they would be altered were not described.

The UK government warned that independence would mean the abolition of the integrated research system, so Scotland would have to build its own research system (HM Government 2013). In this case the Scottish universities would lose their access to the disproportionately high research funding they enjoy. The UK government noted that together, the thriving research base is highly respected across the world.

Furthermore, ‘Researchers from across the UK currently benefit from a highly integrated and interdependent, well-aligned system. This facilitates collaborations between researchers across the UK, as well as projects with industry and overseas academics’ (2013: 7).

Given these diverging visions what might enhanced autonomy mean for Scotland and its system of innovation? Would a more devolved Scotland be better able to alter elements of its innovation system, or would removing itself from the large market and resource base of the United Kingdom have a negative impact? We address the three major questions outlined in introductory section 1 by presenting the results from our

interviews with industrial, policy and academic leaders in Scotland, and from our two workshops, in the next three sub-sections. We do this using Asheim et al.'s RIS theoretical gap categories: effectiveness of RIS for regional advantage; openness and connectivity; human capital and learning.

## ***5.1 Impact of increased autonomy on science base and industry innovation***

We have shown that there is a clear discrepancy between the research base, and the structural features of local industry. There is some interaction between larger Scottish-based international firms and the research base, but absorptive capacity in the local business base is weak. We consider investment, skills, and entrepreneurship and connectivity.

### ***5.1.1 Investment in innovation***

The first major issue relates to the low level of funding for business R&D. The percentage of R&D expenditure to GDP performed in Scottish higher education (0.81%) is higher than the UK average (0.52%), but Scotland's percentage of total R&D expenditures to GDP (at 1.7%) is low (see Figure 4), and lower than other strong science regions within the United Kingdom (e.g. East and South England with 4.3% and East of England with 2.1%). The data reveal that this disparity is driven by the lower performance of the business sector.

Figure 4 here

The business angel investment model in Scotland has matured and contributed to the growth of investment over recent years. However, the situation is not so good with

larger venture capital investments (over £2 million) (Harrison and Mason 2012; Mason et al. 2013). The limited level of VC support makes it hard for angel investments to grow to ‘scale’ and leads to premature sale and relocation from Scotland. One of our business angel leader interviewees articulated: ‘Penetrating global markets needs VC investment which is absent in Scotland’. Finally, Scotland has not been able to attract large investments (over £20m) in sufficient numbers to develop large business skills (Brown et al. 2015).

The Scottish Department for Enterprise, Energy and Tourism, the responsible government department, had a budget of £410.7m in 2011, including £45.2m for industry and technology grants, £283.4m to the enterprise bodies (SE and Highlands and Islands Enterprise) and an Innovation & Industries budget of £5.8m.

In spite of the currently devolved powers, the Scottish Government argued that independence was essential to develop a more effective policy mix to support innovation:

Independence would provide an opportunity to [...] develop a more aligned and coherent framework for innovation in Scotland. A key goal must be to develop a virtuous cycle of activity with close collaboration between key partners in the innovation system – including universities, funding providers, firms and public sector agencies – behind coherent strategic priorities linked to additional economic levers. (2013: 118)

However, this general policy goal was not accompanied by more specific policy objectives.



### *5.1.2 Skills and regional learning*

Scotland does not exploit its human capital as much as it potentially could. 36.9% of Scotland's labour force has tertiary education, which compares well with some other innovative countries (e.g. 35.3 in Finland and 25 in Germany). However, while Scotland fares well in employment in knowledge-intensive services (42.8% of its total employment) in comparison to other countries (e.g. Finland with 41.1% and Germany with 35.3%), in relative terms the highly educated labour force in Scotland is less significantly employed in high and medium-high technology manufacturing sectors (3.9% employment in high and medium-high manufacturing compared with 10.9% in Germany and 7% in Finland) (OECD stats, 2008 values). In addition, there is evidence that Scotland is weak in cultivating commercial and managerial skills that are critical for developing innovations from basic science (Danson 1995; Roper et al. 2007; Freel and Harrison 2007; Coad and Reid 2012; Levie et al. 2013).

With respect to the potential advantages of further autonomy, our interviews and workshops suggested that the issue of human capital was not seen as particularly problematic, which seems surprisingly relaxed given the data above. Some interviewees felt that more autonomy could provide the tools for developing further programmes (e.g. more investment in vocational training), with the needs of the key sectors of the Scottish Economy in mind. Training is already devolved, and the current economic strategy (Scottish Government 2011) already aims to create an education system that is 'responsive and aligned to demand... to support employers by better understanding and assessing the skills required for future success and ensuring that the supply of skills, training and qualifications is sufficiently responsive' (Scottish Government 2011: 126).

However, a range of specific skills and regional learning issues did emerge.

Interviewees from both the life sciences and ICT sectors lamented a lack of critical mass and soft infrastructure (such as financial networks) for cluster emergence.

Reflecting on the possible impact of more autonomy, one key factor pinpointed by interviewees was access to quality human resources (experienced managers, as well as scientists and technicians). The paucity of managerial skills to be employed by new ventures is an ongoing problem for emerging sectors of the Scottish economy (Rosiello 2004), and Levie et al. (2013) point to the relatively low number of female and senior entrepreneurs compared to the rest of the United Kingdom.

In contrast to the emergent life science and ICT sectors, oil/gas and financial services are key sectors that seem less reliant on the local education/research base and training institutions. Interviewees from these sectors expressed that processes of cluster emergence, cumulative learning and competence/skills development had occurred over the past decades within the business environment. The oil/gas cluster located in Aberdeen, and the financial services industry situated around the city of Edinburgh, have nurtured the production of personal skills and technological capabilities now deeply anchored within the local economies.

Nevertheless, a frequently cited example of dysfunctional elements within the Westminster/Edinburgh system of governance was the current immigration policy framework. A significant number of interviewees felt this was preventing the Scottish economy from attracting much needed skilled workers. Interviewees also saw brain drain from Scotland as a challenge. Some research-intensive fields in Scotland do attract significant research funding and are highly competitive, but a stronger industrial base is needed to *retain* graduates from these programmes. One industrial association interviewee noted that: ‘While it’s acknowledged that we do have the

world class research base, there's a real and persistent challenge about absorption of that knowledge particularly among our SMEs'.

As one of our research participants articulated:

the issue on management talent is we do not have multinationals running the business from here. We have satellite R&D teams, not complete bits of the business, so we don't have managerial training effectively taking on risk and getting product definition right, and that's one of the big inhibitors on the whole management stream.

Our interviewees cited the dearth of senior managers capable of running large-scale corporations and starting big initiatives, and a lack of leadership, financial, operational and organizational skills. The lack of large companies in Scotland means that there are not enough role models for SMEs to emulate which, in turn, means that more experienced entrepreneurs leave Scotland, creating a hole in the entrepreneurial skills base. One interviewee, from biotech business, referred to the 'Commercialisation Enquiry Final Research Report' (Royal Society of Edinburgh 1996) on lack of financial management skills and noted that:

It's worth reading it again and seeing what the position is compared to the early 90s. The companies have changed position, the tools are better. There's more availability of venture capital, there's definitely more availability of business angels, you can fund businesses to a certain extent, but there are fewer public companies. Now we all know the issue, the marketplace. But the

ability to raise money and float a company is seen as another tick in your management expertise. There are very few people in Scotland, particularly within the life science sector, that have actually done that in the last 15 years. So we've effectively no flotation. So that's a key management skill that does not exist in the community in Scotland; you would have to go outside.

### *5.1.3 Entrepreneurship and connectedness*

The third area is entrepreneurship and connectedness. Entrepreneurship has long been linked with the emergence, development and growth of new technologies, industries and markets (Schoonhoven and Romanelli 2001). It has always been perceived as a vital component in regional systems of innovation (Ács et al. 2014; Feldman 2014). It consists of a process of recognizing and realizing new ideas through a co-evolutionary process in which the emergence and diffusions of entrepreneurial capacity and the emergence and realization of new knowledge-based opportunities are jointly inter-reliant. The beginning of new domains coincides with the intimate interaction between interdependent practitioners within (regional) entrepreneurial networks; networks develop, and the domains expand and become embedded in regional systems. As the knowledge necessary to answer new technical questions expands, new network connections are established and old ties deteriorate in a continuous process of renewal of knowledge, entrepreneurial activity and industry structure. On top of the lack of connection between science and the industrial base and in spite of Scotland's strength in some technologies, there is a lack of inter-sectoral and inter-regional connectivity and networking activities to support entrepreneurial innovation (Figure 3). For example, one interviewee pointed out that major learning synergies could arise from the exchange of knowledge and the transfer of skills from the

established oil/gas sector into renewable energy, and another stressed the pervasive nature of ICT and innovation opportunities arising from its extensive application to both existing (oil/gas) and new sectors (e.g. life sciences) of the economy. These views are consistent with recent developments in RIS and regional policy literature, which point to the importance of learning and growth opportunities arising at the interfaces of related sectors of the economy (Boschma and Frenken 2011) and through the diffusion of general purpose technologies (Aghion et al. 2009). Furthermore, a number of business participants were extremely fearful of the possibility of leaving the European Union because of the importance of their knowledge and commercial networks across the continent.

Scotland has articulated a strategy of diversification from finance and oil and gas towards sectors such as information and communication, life sciences, engineering and renewables. A recent strategic priority has been to encourage internally driven growth based on local capabilities, to use Scottish capabilities to bridge the gap between science and innovation (SE 1996, 2001). This approach depends strongly on building entrepreneurial capacity in areas such as biotechnology and renewal energies, and expanding it in areas such as ICT.

Our findings suggest that further autonomy will have mixed impact. As our respondents emphasized, further autonomy would mean greater powers for policy-makers to design and implement policies for clustering and facilitating networking among firms. However, Scotland already has considerable powers along these lines.

There is varied awareness from business and policy leaders concerning how increased autonomy might improve business absorption of knowledge. The focus on science-led innovation measures over building firm-based innovative capabilities is a major constraint. Business leaders and policy-makers tended to speak more in terms of

science than of improving the connectivity between firms and between firms and knowledge enhancing and learning activities. There is general awareness of the mismatch between the research and knowledge base and the industrial system in Scotland, but less specific consensus on what might be done. There was a strong focus on firms need for patient and risk based capital, but less clarity on the importance of infrastructural and network building. On human capital and learning, business leaders were not particularly concerned about training and absorption of skills, though they were aware of the lack of big company business and management expertise (see Figure 5).

## ***5.2 Impact of increased autonomy on the organizations that support innovative activities***

Sustaining and growing successful and innovative industries depends on a range of services and policies (Muller and Zenkes 2001; Morgan 2007). Our interviewees agreed that the innovative capacity of local firms and sectors depended on the preservation and expansion of infrastructure for supporting innovation, alongside changes in the tax regime, regulatory environment, and preserving excellence in the higher education system.

Sceptics of enhanced powers to the Scottish Government and an autonomous Scottish innovation strategy pointed out that the emerging sectors of the local economy are currently reliant on the support of IUK, with very significant funding (£1bn per annum). IUK spans a greater innovation policy and delivery range than SE. Scotland received some 10 per cent of IUK funding in 2012.

Some interviewees felt that the UK Government had more potential to increase innovative activities through public procurement, for instance in defence-related contracts to Scottish engineering companies. But even sceptics were in support of improved innovation infrastructure.

Those who support more autonomy focus on the advantages brought by a more comprehensive strategy, tax incentives for innovation, an immigration policy aimed at attracting skilled workers, and a more active role for the public sector in promoting innovation. With regard to this coherent industrial strategy, one oil and gas business interviewee made the following observation concerning successful earlier support towards innovation:

If I can take you back a moment to the early days of North Sea oil and gas development, at the time, Scotland and England were characteristically different. [...] They were not in the short-term markets of the City of London. They were in it for long-term capital growth. [...] Now it seems to me there's an element of that in the current debate about what happens next. Scotland is still wealthy in a lot of resources. For instance, it is land-rich, huge potential in terms of the next 100 years when land is going to be at a premium, wherever you look anywhere in the world.

The cases of Norway, Switzerland and Denmark were also cited as examples of small countries with frameworks of innovation support that have been strategically and coherently developed according to their evolving needs. An IT business interviewee observed that:

I think there's every reason to suppose that it won't be easy, it might be a messy period for a while. So, the whole of the Scottish economy might not do very well for 10, 15, 20 years. But then, I do think there's no reason on earth why Scotland couldn't configure its economy to be more like a Scandinavian country. ... These are among the most prosperous countries in the world and the quality of life in them is very good, there's no particular reason why we shouldn't be in that situation.

In summary, our interview and workshop data allow identification of key issues of particular concern regarding the preservation/expansion of existing innovation infrastructure, focused particularly on effectiveness of RIS for regional advantage and openness (Figure 5). Our data suggest that there is good general understanding of, and support for, the strengthening of innovation infrastructure in Scotland, though a major group of senior opinion leaders believe that the strengthening should not come at the expense of reduced access to UK level infrastructure. Surprisingly, this general support was not accompanied by specific policy suggestions concerning for example: the importance of increased connectivity between territorial innovation infrastructure and firm competitiveness; support for network development; and improved systems for building labour market competitiveness of middle and senior management.

### ***5.3 Innovation and new path development***

Interviewees from emerging sectors voiced different concerns regarding innovation. For example, research-intensive industries, such as ICT and life sciences were more



interested in R&D tax credits, grants for innovative projects, and private equity/credit available for risky ventures. In this sense, the existence of a Scottish Investment Bank was seen as a positive feature of the existing SIS. The recent recession created profound challenges for many companies in accessing capital beyond early stage equity. In response, the Scottish Executive rebranded SE's investment team as the Scottish Investment Bank in December 2010. Crucially, the bank expanded its remit to support the development of Scotland's private sector SME funding market to ensure that both early stage and established companies with growth and export potential have adequate access to growth capital. Some of our interviewees saw this as an important development, a model that should be preserved and extended in an independent Scotland alongside tax reliefs.

Our interview data strongly suggest that innovation and structural change will take time since emerging sectors, such as life sciences and renewable energies are in an embryonic stage of development, whilst ICT has not yet reached critical mass. As noted earlier, Scotland does have a strategy and potential for strategic industrial diversification. However, not only does new path development depend on increased investments and the transfer of critical skills, but also on crucial factors in the regulatory environment. That is, economic activities in sectors such as oil/gas, financial services, ICT and bio-pharmaceuticals are critically reliant on rules dictating how natural resources can be extracted/handled, drugs safely produced, financial services prudently and transparently offered, and intellectual property used. Some interviewees raised concerns about new regulatory frameworks and the time and resources needed to develop them. One biotech company interviewee said:

Currently in the healthcare system for example, when you invest in a company in the UK that's got a UK market, you deal with the MHRA. You know how the process works. In an independent Scotland the regulator is not based in Scotland. You may contract with the MHRA, but how does that work? My biggest concern is anything that creates doubt in the venture capital organisation.

The Scottish Government has highlighted that nurturing and promoting an entrepreneurial culture would constitute a strategic priority. There was less certainty about implementation plans.

Crucially, our interview data suggest that, as autonomy is enhanced, the current infrastructure to support entrepreneurial and absorptive capacities needs to be significantly improved (Figure 5). Some interviewees felt that independence would force local economic agencies to take more responsibility and policy-makers to develop the conditions for a stronger entrepreneurial culture and the expansions and integration of sectoral knowledge networks.

On this third research question, there was general consensus on the potential of increased autonomy to improve the RIS environment for structural change and improved innovation capacity. Nevertheless, although the issues raised are crucially important for building innovative capacity, there was less sense of a serious coherent push for systemic programmes, whether of a sectoral and networked nature, or even more generally of a regionally coherent innovation policy, geared to the evolving and emerging knowledge-intensive and less successful and traditional industries.

## 6. Conclusions

The article set out to understand the key issues regarding innovativeness within the Scottish economy in the wake of the referendum of 2014, addressing three research questions concerning the impact of increased autonomy, and using the theoretical gaps in RIS research identified by Asheim et al. (2011). The article's data reinforced existing evidence that Scotland's strong science base is weakly linked with innovation capacity. Our data describe the serious 'disconnect' between scientific/educational capacity on the one hand, and innovative and entrepreneurial capacity on the other. The article provides data on the main concerns and informed opinions of the business, policy and research communities concerning the SIS suggesting that the community is not clearly articulating the relative lack of development of a new SIS in the period since devolution.

After Scotland decided to stay part of the United Kingdom, increased autonomy is planned. Further uncertainty includes the Brexit vote. The questions raised in our study thus remain extremely relevant. How could enhanced autonomy improve innovation in the Scottish economy? The data point to a series of conclusions. First, the desire for a more aligned and coherent innovation policy is generally shared among the business community. However opinions diverge as to whether such a strategy could be more effectively delivered by a Scottish Government benefiting from full autonomy with micro-economic and innovation policy, or through a realignment of the responsibilities and powers within the UK-wide system of innovation. Overall, the overwhelming opinion is that a gap has to be bridged, but weak understanding that a new innovation system has to be built.

Second, the community sees innovation as a science-led issue. The business community sees the Scottish universities as a huge advantage to economic

competitiveness, but only a minority think that an innovation-led policy might need to change research priorities, at least to an extent.

Third, there is a general awareness of the current disconnect between the science base and the industrial sectors of the Scottish economy, though solutions are couched in terms of bridging a gap rather than as needing an evolutionary and dynamic process.

Fourth, there was a general consensus that structural change within the Scottish economy is required to secure long-term prosperity. The emergence of a stronger entrepreneurial culture is seen as a *sine qua non* condition to take advantage of the potential for innovation that resides at the interfaces of emerging sectors of the economy such as life sciences, creative industries, renewables and engineering, but also food/drink and tourism.

RIS theory provides an alternative to go beyond ‘good science... poor innovation’ and instead look at existing and potential economic activity in Scotland so as to improve the innovative potential across the broadest range of industrial sectors – an integrated innovation systems approach. The situation of Scotland with its potential for significant structural change provides a particularly interesting example to illustrate Asheim et al.’s argument on the theoretical gaps in RIS research. Our data provide a good illustration not only that Asheim et al.’s approach is extremely useful, but also shows that disconnection exists not just between the science and innovation ecosystems but between sectoral knowledge networks in the SIS, and thus in a modest way contributes to filling the theoretical gaps they identify.

It allows us first to detail the weak link between regional innovation strengths and regional competitive advantage: in food and drink, finance, tourism, oil and gas, renewables and informatics. Then second, we were able to show the weak policy conceptualizations of network construction and connectivity, and the need for a more

open regional/national system that looked for connections between strong and/or emerging sectors on the one hand, and weaker and/or declining sectors on the other. Finally, we showed that the excellent higher educational system did not translate particularly well into a workforce for the emerging and dynamic productive sectors. The main perceived problem is the number/quality of opportunities offered by local businesses. The emergence of new domains of technological and industrial activity, alongside the renewal of existing economic specializations, are therefore required, in line with the Scottish Government (2013) economic policy approach. However, with the exception of the recognized need to support the inflow of skilled workers and strengthen financial support for innovation and entrepreneurship in extant and emerging sectors of the economy, our data (across the six sectors of the Scottish economy surveyed) does not show any consensus about whether increased autonomy would allow for a more integrated and systemic policy approach, which seems necessary to address the disconnect between areas of scientific excellence and domains of economic specialization. Such a consensus is key for the implementation of the next phase of European territorial innovation policy – smart specialization (Foray et al. 2011). Certainly, taking greater account of smart specialization would require far-sighted awareness of present and potential future new industrial path development. This process cannot rely uniquely on present science strengths, but also on recognizing processes of ‘entrepreneurial discovery’ (Foray et al. 2011) for which the policy capabilities (Von Tunzelmann 2009) developed since the start of the devolution process seem crucial.

Overall, there seems to be agreement that the economic future of Scotland depends not only on increased autonomy but on an integrated innovation system with a strong and growing emerging set of industrial sectors. While this is key to the smart

specialization strategy and, indeed, the relevant policy literature already stresses the importance of ‘connectedness’ through inter-sectoral and trans-regional networks (McCann and Ortega-Argilés 2013; OECD 2013), our survey data show that the required level of connectedness may be lacking, presenting a challenge to regional governance regarding the implementation of the smart specialization agenda. The data suggest that the Scottish government could productively focus on ways of creating cross-pollination of knowledge and ideas from areas of strength in Scotland to those areas that are weaker, although this would need to be balanced by a good understanding of the sector specificity of innovation systems. At the same time, government can work to improve ways of attracting and retaining human capital in areas of large company management. And changes in science funding, around which the Scottish Government has considerable control, could include learning from Scandinavian experiences and analyses (see e.g. Cooke and Eriksson 2011).

Our study used the concept of RIS to shape our perspective on regional dynamics and on the policy mechanisms that can improve the innovation system. The Scottish case suggests that improvements are possible, but that the biggest gains from taking a RIS approach would arise if the RIS approach began from the firm, and from building networks of firms linked to an improved RIS infrastructure. The RIS approach can thus be further strengthened by focusing on the role of the firm: from the position that firms find themselves in, the potential trajectories that firms and sectors might evolve, and the processes that might help them to do so.

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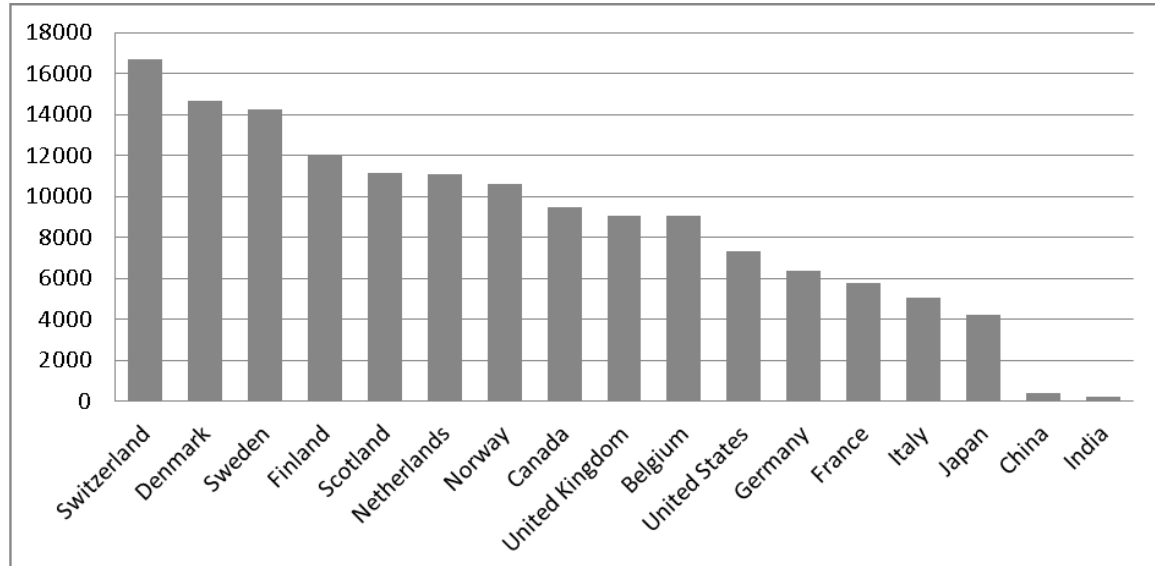
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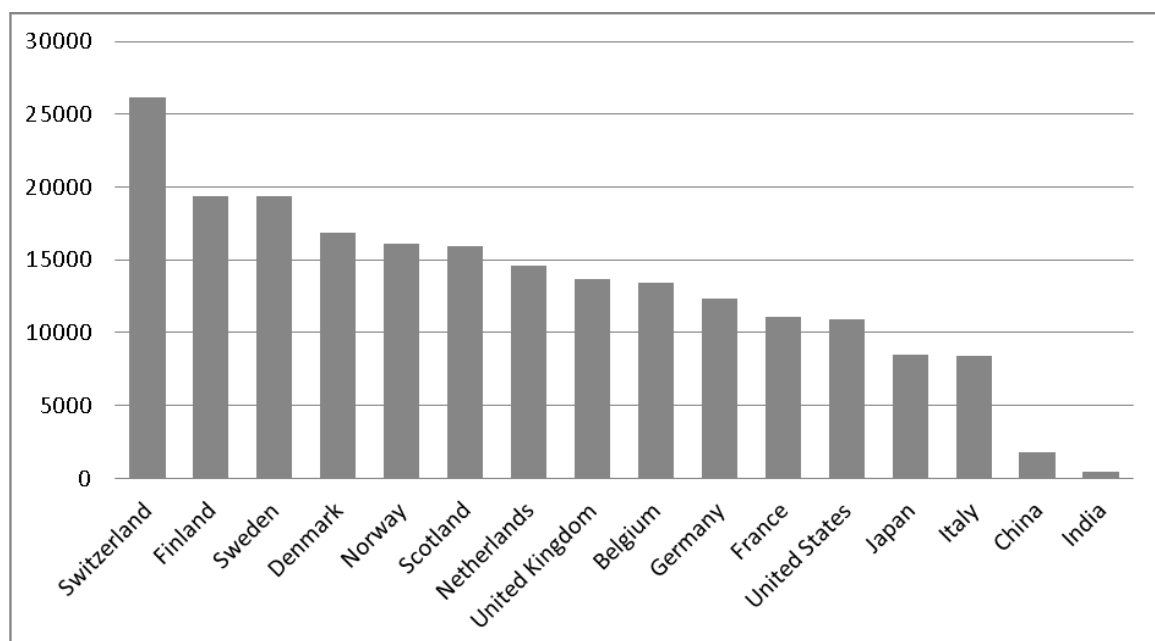
E-mail: [david.wield@open.ac.uk](mailto:david.wield@open.ac.uk)

**Figure 1: Publications in life sciences per million population (1996-2012)**



Source: Authors analysis of Web of Science data

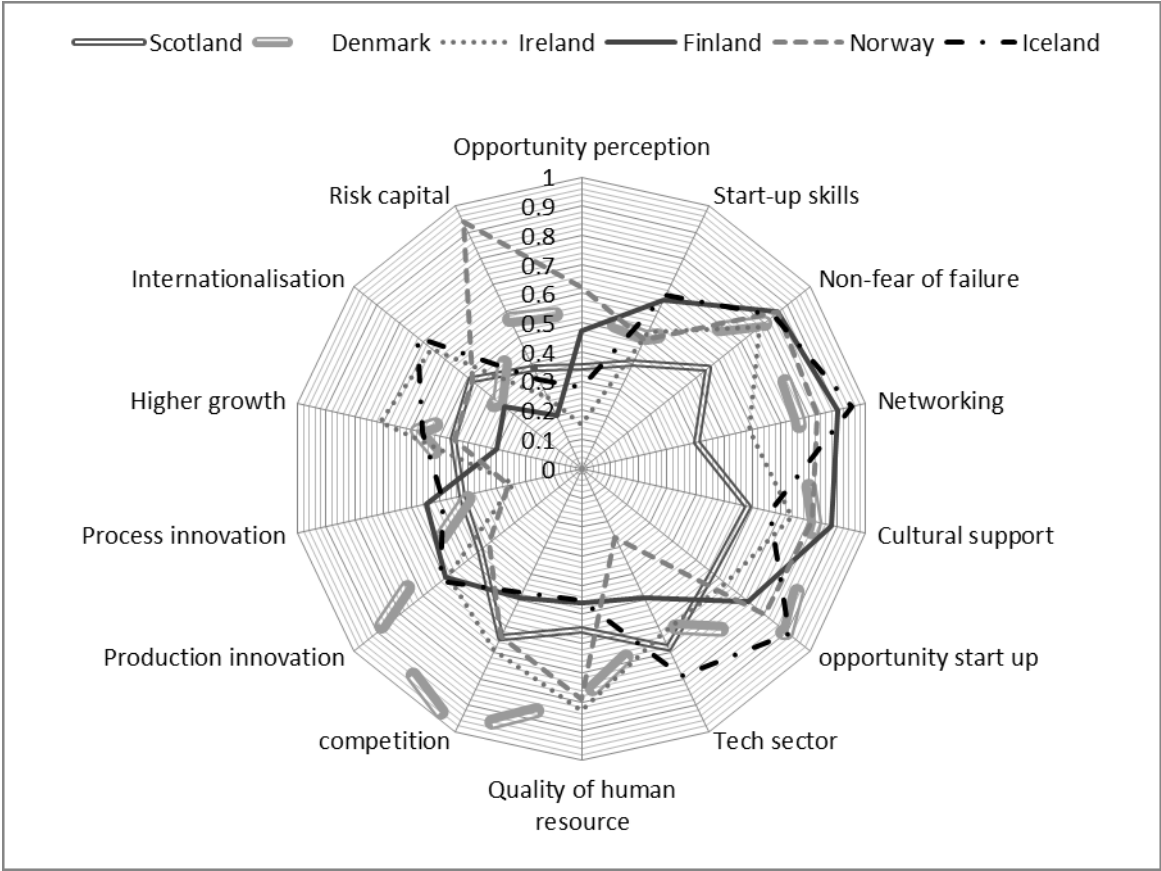
**Figure 2: Physical sciences publications per million population (1996-2012)**



Source: Scopus database

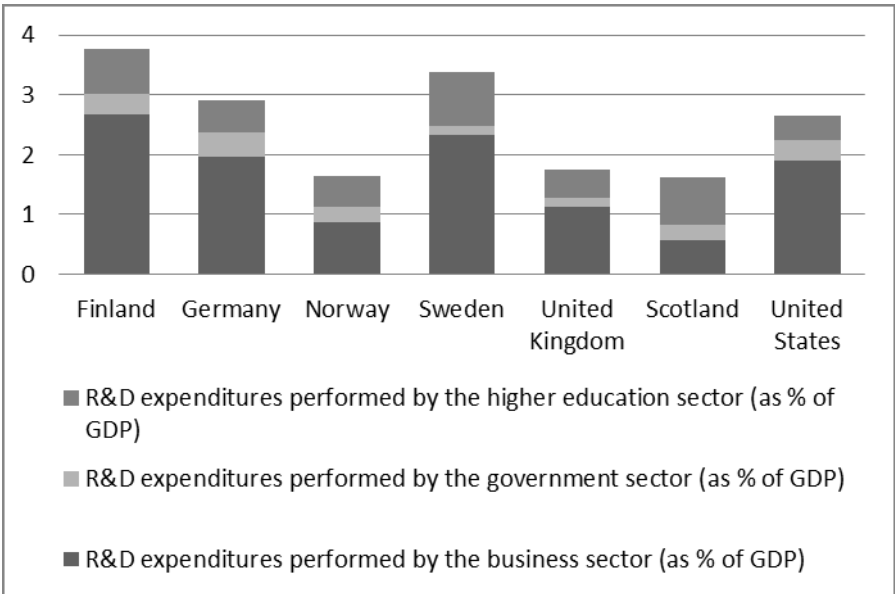


**Figure 3: Scotland’s innovation-based entrepreneurship ecosystem compared with ‘Arc of Prosperity’ economies**



Source: GEDI (the Global Entrepreneurship and Development Institute)- 2013 Values

**Figure 4: R&D expenditures as GDP percentage – 2011**



Source: OECD iLibrary

**Figure 5 Issues raised concerning impacts of increased autonomy: on ability of Scottish business to absorb knowledge and apply it to their innovative activity (RQ1)**

Issues	Emphasis of respondents	Type of Asheim et al gap
<b>RQ 1 Ability of Scottish Business to absorb knowledge and apply to innovative activity</b>		
Low level of business R&D	Much less emphasised than the emphasis on science and research funding	RA
Low entry of large companies and medium and big investment	Identified by some, but rather weakly addressed	RA
Need to diversify from oil/gas and finance to emergent and new sectors	Acknowledged, but with weak specific recommendations	RA, OC
Low level of management, start up experience, and entrepreneurial experience	Acknowledged quite strongly, with support for SE. No strong concerns about the lack of employment opportunities in emergent and new sectors. No specific policy proposals	KL
Lack of critical mass and soft infrastructure for cluster emergence	No clear pointers to improve situation	RA, OC
<b>RQ 2 Organisations that support Scottish business in their innovative activities</b>		
Need to preserve and expand existing infrastructure for supporting innovation	Scottish Government (2013) argued that independence would provide opportunities to develop a virtuous cycle, by linking support for R&D, Innovation, Entrepreneurship and Fiscal Policy. Lack of funding for creating infrastructure. Lack of critical mass in sectoral domains	RA, OC
Sectorally tailored support by SE for sectors like creative industries, energy, finance, food and drink, life sciences etc  Innovation (Proof of Concept, R&D grants, SMART:Award, Innovation Centres etc) Support for sectoral networks Support for exporting activities (SDI)	Support for continuation and strengthening. No specific policy proposals.	RA, OC
Use of public procurement	No concrete proposals	RA, OC
Skill base needs to better respond to needs of business	No concrete proposals. Appreciation for past initiatives such as 'Global Scot'.	KL

